CHM129

Acid-Base Equilibrium: Weak Acids and Bases

1. A 0.020 M solution of niacin has a pH of 3.26. Calculate the percent ionization.

$$[H_3O^+] = 10^{-3.26} = 5.5 \times 10^{-4} M$$

$$\% \text{ ionization} = \frac{[H^+]_{equil.}}{[HA]_{ini}} \times 100$$

$$\frac{5.5 \times 10^{-4} M}{0.020 M} \times 100 = 2.7\%$$

2. A 0.100 M weak acid (HA) solution has a pH of 4.25. Find K_a for the acid.

$$HA_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

$$[H_3O^+] = 10^{-4.25} = 5.6 \times 10^{-5} M$$

	[HA]	$[H_3O^+]$	$[A^-]$
initial	0.100	0.00	0.00
change	-5.6×10^{-5}	$+5.6 \times 10^{-5}$	$+5.6 \times 10^{-5}$
equil.	$0.100 - 5.6 \times 10^{-5}$	5.6×10^{-5}	5.6×10^{-5}

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{(5.6 \times 10^{-5})(5.6 \times 10^{-5})}{(0.100 - 5.6 \times 10^{-5})} = 3.1 \times 10^{-8}$$

3. Find the pH of a 0.100 M $HC_3H_5O_2$ solution. $K_a = 1.3 \times 10^{-5}$

$$HC_3H_5O_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C_3H_5O_2^-{}_{(aq)}$$

	$[HC_3H_5O_2]$	$[H_3O^+]$	$[C_3H_5O_2^-]$
initial	0.100	0.00	0.00
change	$-x$	$+x$	$+x$
equil.	$0.100-x$	x	x

$$\frac{[HC_3H_5O_2]}{K_a} = \frac{0.100}{1.3\times10^{-5}} = 7.7\times10^3$$

> 400 Assume x is small

$$K_a = \frac{[H_3O^+][C_3H_5O_2^-]}{[HC_3H_5O_2]} = 1.3\times10^{-5}$$

$$\frac{(x)(x)}{0.100-x} = 1.3\times10^{-5}$$

$$\frac{x^2}{0.100} = 1.3\times10^{-5}$$

$$x = \sqrt{(0.100)(1.3\times10^{-5})}$$

$$x = [H_3O^+] = 0.0011\,M$$

$$pH = -\log[H_3O^+] = -\log(0.0011)$$

$$pH = \underline{2.96}$$

4. What is the pH of a 1.5 M $(CH_3)_2NH$ solution? $K_b = 5.9 \times 10^{-4}$

$$(CH_3)_2NH_{(aq)} + H_2O_{(l)} \rightleftharpoons (CH_3)_2NH_2^+{}_{(aq)} + OH^-{}_{(aq)}$$

	$[(CH_3)_2NH]$	$[(CH_3)_2NH_2^+]$	$[OH^-]$
initial	1.5	0.00	0.00
change	$-x$	$+x$	$+x$
equil.	$1.5-x$	x	x

$$\frac{[(CH_3)_2NH]}{K_b} = \frac{1.5}{5.9\times10^{-4}} = 2.3\times10^3$$

> 400 Assume x is small

$$K_b = \frac{[(CH_3)_2NH_2^+][OH^-]}{[(CH_3)_2NH]} = 5.9\times10^{-4}$$

$$\frac{(x)(x)}{1.5-x} = 5.9\times10^{-4}$$

$$\frac{x^2}{1.5} = 5.9\times10^{-4}$$

$$x = \sqrt{(1.5)(5.9\times10^{-4})}$$

$$x = [OH^-] = 3.0\times10^{-2}\,M$$

$$pOH = -\log[OH^-] = -\log(3.0\times10^{-2}) = 1.52$$

$$pH = 14.00 - pOH = 14.00 - 1.52 = \underline{12.48}$$